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# THE RELATIONS OF PLANT PATHOLOGY TO THE OTHER BRANCHES OF BOTANICAL SCIENCE

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When asked to open this discussion upon the relations of plant pathology to the other branches of botanical science I was somewhat puzzled as to the course to pursue. In the first place I hesitated to attempt a defense of the wording of the topic itself. Is plant pathology a distinct branch comparable to "other branches of botanical science?" Much of the work of the phytopathologist concerns the fungus and bacterial parasites yet the bacteriologists and mycologists may well regard as unscientific any attempt to subdivide their fields by the segregation of the groups of organisms parasitic upon the higher plants. It is equally clear that the problems of plant pathology concern chiefly the diseased plant, but the abnormalities involved are primarily physiological, and how can the abnormal in plant physiology be scientifically considered apart from the normal? Certainly the mycologists on the one hand and the physiologists on the other have a right to scan with critical interest any attempts at such artificial delimitations and to ask of those concerned in them explanations in defence of their course. Nor do the embarrassments of the phytopathologist stop here. The horticulturist and the agronomist each has his field and where are the problems of the plant pathologist if these are not to be invaded? Nor can we plead that the overlapping is merely temporary and that with the advance of scientific knowledge the problems of the plant pathologist are to be more clearly segregated from these related branches along natural lines of cleavage; rather is the reverse true. Why, then, the assumption of an awkward distinguishing name; the organization of a separate society; the start-

[1] Read before the Botanical Society of America, Minneapolis, Dec. 29, 1910. This was the first of three papers in a Symposium on Some Aspects of Plant Pathology. The others will be published in succeeding numbers of this journal, viz.: Physiological Plant Pathology by B. M. Duggar and Resistance and Immunity in Plant Diseases by E. M. Freeman.

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ing of new courses, indeed of departments, in the universities; the publication of text-books and of independent journals?

The reply is simple and we believe practically sufficient, even though not quite satisfying scientifically. It is *to secure greater efficiency in service*. Modern developments in plant culture have created an urgent need. Botanical science is expanding its organization to meet the need. Service always means some distraction from ideals, always entails temporary sacrifice. But in science, as in other human pursuits, service is in the end indispensible to the highest development.

If this claim is legitimate, and the plant pathologists are permitted, on the grounds of expendiency, to segregate these problems from their more natural associations, this does not affect their fundamental relationships. It simply increases the responsibility of those who make the move. The advance of plant pathology will be just in proportion to the clear recognition of the fact that its chief problems are biological rather than economic, that the primary concern must be with the uncovering of physiological relations and principles rather than the field trial of fungicides of whose composition even we are ignorant and the formulation of empirical rules of which the breadth of application is at least doubtful. This means grappling with problems of the most varied nature and exceeding complexity. And the variety and complexity promise to increase with the progress of the work.

Success along these higher lines is at present less than it should be because of lack of specially trained investigators. In years to come the need for such training will become still more imperative. Unfortunately the demand for young men in plant pathology has increased faster than the supply of well trained specialists. This has resulted in drawing many of them into the work without adequate preparation. One of the most important services that can be rendered the profession is to counteract this tendency and see that at least the most capable of these young pathologists are advised and stimulated to train themselves to the highest possible degree for their work. And this raises the special point which seems to me deserving of critical consideration in this Symposium, viz: What is the best training for the specialist in plant pathology? It is easy to reply that there is no single ideal way—that it must vary with the man, his special aims and the opportunities offered by the institution. But, granting this in part, all must yet agree that there are some main features which should be common to all if obtainable. Not all who assent to this general principle, however, may agree as to just what are these most important things. It will, nevertheless, be helpful if we can learn where we agree and where there is difference of opinion. In order to

prepare myself the better to outline these for discussion, I recently sent a letter of inquiry to several of our colleagues, who have had experience in directing such work. While I must not hold them responsible for the conclusions I have reached, I wish to thank them for strengthening my own judgment at numerous points and in suggesting new ideas at others.

Of course, all educators wish to begin with the child, so in the following summary of what I would term the ideal training for the specialist in plant pathology I will begin with the preparatory stages, then the undergraduate course, and finally the graduate studies.

1. The thing I would place first is *early and sympathetic acquaintance with the practical aspects of plant culture*. This is best secured by a boyhood spent on the farm, especially where horticultural interests predominate. For the city-bred boy it is to be supplied and for the country boy it may be increased by summers spent in stimulating horticultural or agricultural environment.

2. *An early start in discriminating field observation of plants*. This is best secured, I believe, by an introduction to systematic botany under a competent and inspiring teacher, followed by continued field studies during the summer until keen observation becomes a habit.

3. *Early training in foreign languages;* best in Latin and German in the preparatory school with advanced German and French as an undergraduate in college. A fair reading knowledge of these two should be secured before graduation and this should be perfected by continued practice thereafter.

4. An introduction before the middle of the college course to the *right scientific methods and ideals*. This may be best secured, according to our experience, in connection with college courses in chemistry and biology. If the student has the right stuff in him he will thereupon decide to follow some scientific profession though his final decision favorable to plant pathology may not come until later.

5. *A thorough grounding in chemistry*. At least two years of undergraduate work in chemistry and better three, to include a thorough grounding in general chemistry with an introduction to organic.

6. *Botany*. The preparatory and collegiate courses, supplemented by summer work, should include a broad general course; systematic work on the seed plants, especially field work; a general course in plant physiology; and a general course in either bacteriology or mycology. This will require some preparatory school work and of collegiate work a minimum of two years and a maximum of two and one-half or three.

Here I will stop prescribing preparatory and undergraduate courses. The omissions may excite more discussions than the inclusions. For example, I have not specified whether these are to be secured in a classical course or an agricultural. If the preparatory training is right the college work specified may be had in a broad college course of either type. Probably they will come most naturally in a Latin-scientific preparatory course followed by a general science course in College. Nothing has been specified as to physics, zoology, including animal physiology and entomology, geology, or English. We must assume that some of these will receive adequate attention in the undergraduate years. It were desirable if all were well covered before taking the bachelor's degree, but this will rarely be practicable, and such gaps as remain must be filled later.

Finally, no mention is made of plant pathology itself. It will be helpful if some introduction to the subject can be had in connection with the mycological and bacteriological courses, but any detailed consideration belongs to the graduate years. I would rather have none than to have much time taken from the more general and fundamental courses. There is, however, one addition which I consider highly desirable. It is that, if senior thesis work is undertaken, it be on some problem in plant pathology. This is not primarily for the added technical training. Quantitatively I would quite as soon that would lie in the field of chemistry, bacteriology or German. It is rather as a probationary exercise. If there is any lack of fitness it is detected then. If, on the other hand, the work is well done the impression made by it at that stage in the student's development may be great and lasting. Indeed, this senior thesis work may have more educational significance than any corresponding work in the first graduate year.

But, of course, the important technical training must come in the graduate school. Emphatically, the time has come when no young man should be permitted, much less encouraged, to continue work in plant pathology as a profession who has not at least his master's degree. The time will come when we shall say doctor's instead of master's, and so far as practicable this should be our standard now. Granting that a student is to give from two to four years to graduate studies looking to this profession, what are the essentials to be included? Of course, there are many details which can not be prescribed for all alike. These will depend upon previous training, individual predeliction, local opportunity to work with men of peculiar strength, and the special phase of plant pathology toward which one hopes to turn. But, granting all this, there are again certain things to be emphasized for all men alike. What are they?

1. *Chemistry.* Such further work in quantitative or other lines as will supplement the general training already received, and a thorough advanced course in organic chemistry. Chemistry laboratory courses should for most students, continue through two years of the possible three or four given to graduate studies.

2. *Plant Physiology.* Unless already taken there should be a thorough course with especial emphasis upon nutrition and reproduction, including the laws of heredity. This should either be given from the standpoint of cellular physiology or supplemented by a course in cytology including the physiology of the cell.

3. *Mycology.* Providing there was not a thorough undergraduate course in mycology, such a course should be taken as a graduate.

4. *Bacteriology.* Enough in addition to any undergraduate course to total at least one year's training in bacteriology.

5. *Minor courses:* Histology, entomology, horticulture, including plant breeding, agronomy. In some of these sufficient introduction is obtainable in the undergraduate course, especially as supplemented by summer experience. If such is lacking brief general courses are desirable, although not always practicable.

6. *Plant Pathology.* This is, of course, to be the major subject. Even so, it may well be held in abeyance as a time consuming topic for the first year in order to give place to the completion of the fundamental training outlined, especially in chemistry and botany. Perhaps one-fourth or one-third of the time of the first year may be given to plant pathology, including some critical seminar and library work and the beginning of earnest research. Work in course during this year and the next should supplement any undergraduate work so as to include a general introduction to plant pathology, a consideration of non-parasitic as well as bacterial and fungus diseases, remedial measures, including the chemistry and uses of fungicides, tree surgery, and the technique of research methods in laboratory, greenhouse and field. Much of the time during the summer months should be given to observational or experimental studies in the field, preferably in relation with the students' major problem, but not forgetting contact with the work of others and miscellaneous observation and collecting. The major research will occupy an increasing proportion of time during the last two years, presumably practically all of the time of the last year.

While in all this work the aim is to insure broad and thorough fundamental training, we must beware lest by its very breadth and weight we smother rather than stimulate. This stimulus and inspiration so far as it comes from others must be furnished in part by

personal encouragement in the development of his individual problem —in part by the general atmosphere of the research laboratory and seminar. The student must from the outset be led to realize that method is worth more than substance in any course, and in his choice of courses and his work upon them, this is to receive first consideration. Coupled with this must be the conviction that research work is serious—that, if he is to enter upon it, his individual training must be of the best, and that his individual initiative is a determining factor. In other words, he must appreciate the importance of his personal work and individual responsibility, while at the same time he must recognize the numerous points of contact of his work with that of others. He must realize the complex inter-relations of scientific phenomena. He must see that in his work he is to act, not as an individual, but as one of a large company. His work is of greatest value only as it is correlated. He must familiarize himself with what has been done and keep constantly in contact with what is being done by others. While he is to strive to his utmost as an individual, he is to strive not for his individual preferment and glorification, but for the advancement of the science of plant pathology. For this is needed, not individual specialization alone, but team work ; coördination with what has been done by our predecessors, coöperation with what is being done by our contemporaries and associates, patient painstaking preparation for further work to be done by those who are to follow.

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# A BACTERIAL DISEASE OF BANANAS AND PLANTAINS

JAMES BIRCH RORER

(WITH PLATES VII–X.)

The uses made of bananas and plantains in Trinidad are almost as numerous as the varieties cultivated. All the different kinds of "figs," as banana fruits are called locally, with the exception of the red which is considered a febrifacient, are eaten raw in large quantities by all classes of people while the plantains, baked, boiled, fried or pounded take the place, to a great extent, of bread and potatoes. When caught in a sudden shower of rain a large banana leaf serves excellently as an umbrella. The baker always puts a small strip of leaf across the top of the loaf of bread to make it rise well; while pastelles, tomale like luxuries, are wrapped in banana leaves instead of corn husks. In cacao cultivation the plant is all important. The green leaves, spread out on the ground, form an excellent mat on which the cacao beans are collected in large heaps, while the plants themselves serve as a mulch when cut down and spread over the soil around the trees.

Some variety of Musa is always planted with young cacao trees not only to shade the ground, but to serve as a source of income as well until the cacao comes into bearing. Bananas will probably never be grown on a large scale in Trinidad on account of the lack of suitable soil in large areas and of unfavorable climatic conditions, yet the plants will always be cultivated for local use and in the cacao plantations, so that any disease affecting them is of interest from a practical as well as a scientific standpoint.

In the latter part of 1909 the attention of the writer was called to a disease of the "moko" fig, a variety of plantain, which at one time was grown largely for shade in young cacao plantings. The variety was admirably adapted for the purpose because of its hardiness and the quickness with which the plants ratooned. About twenty years ago, however, an epidemic practically wiped out this variety so that now it is but rarely met with, and its place in cacao cultivations has been taken by the "sucrier" or lady finger banana.

A few diseased "moko" plants were found on an estate in the central part of the Island. An examination showed that the vascular bundles were filled with bacteria, which oozed out in white shiny drops from the cut surfaces. Pure cultures of an organism which was proved to be the cause of the disease, were obtained by the poured plate method. As this disease was evidently different from that

described by Earle[1] from Jamaica, and that found in Porto Rico[2], the only two diseases of bananas supposed to be caused by bacteria to which reference could be found, a brief report was presented before the Agricultural Society of Trinidad and Tobago by the writer.[3]

More recently the disease has been found in practically all parts of Trinidad attacking not only the "moko" plantain but the Creole and French varieties as well (*Musa paradisiaca*) and the dwarf or Cavendish banana, (*Musa chinensis*) which has been planted largely to replace the Gros Michael.

The presence of the disease is as a rule first detected in the lower leaves. The leaf-blades droop a little more than usual and have a slightly yellowish tinge, symptoms very similar to those brought about by drought. Soon however the petiole of one of the leaves gives way just at the base of the leaf-blade, and all the other leaves quickly break down in a similar manner. Eventually the terminal leaf, too, bends over and the plant dies and rots down to the ground. (Plates VII, VIII and IX.)

Transverse sections of the pseudo-stem show that practically all the vessels are discolored, (Plate X, Fig. 1.) the color ranging from pale yellow to dark brown or bluish black, and filled with bacteria. The discolored bundles run back into the true stem and thence into the young suckers and buds. (Plate X, Figs. 2, 3, and 4.) Sometimes in badly diseased plants the tissues of the leaf-stalks and stems are broken down completely so that fairly large bacterial cavities are formed. (Plate X, Fig. 4.)

If transverse sections of leaf or stem are let stand for a short time the cut surfaces soon become covered with bacterial drops which have been forced out from the ends of the bundles. If the sections when freshly cut are put in large covered dishes away from the air, pure cultures of the organism may be obtained directly from these drops. If the disease is not severe, or a plant does not become infected until it has just formed a bunch of fruit it may remain perfectly healthy looking, but many of the young fruits, or "fingers" do not properly mature; they remain small and eventually become black and rotten. In such cases it is found that there are some discolored bundles filled with bacteria in the leaves, stem, fruit-stalk, or fruits. When diseased suckers are planted the terminal leaf frequently turns black and dries up so that the plant dies.

[1]Earle, F. S. Report of a Trip to Jamaica. Journal, New York Botanic Garden 4: 8. 1903. (Reprinted in West India Bulletin 4: 6. 1904.)

[2]Porto Rico Agricultural Experiment Station, Annual Report for 1904.

[3]Rorer, J. B. A bacterial disease of bananas and plantains. Proceedings of the Agricultural Society of Trinidad and Tobago 10: 109-113. April, 1910.

The organism which is the cause of the disease was first isolated and grown in pure culture in August 1909 and since that time numerous successful inoculations and reisolations have been made. The first inoculation was made on October 13, 1909. A three weeks old culture on slant potato agar was used. Ten cc. of sterile water were added to the culture and the bacterial film was loosened with a sterile platinum loop so that the organisms became suspended in the water. Two cc. of this mixture were injected with a hypodermic syringe into one of the upper leaves of a half grown plant in a well rooted stool of "moko" plantains at the Botanic Gardens. This plant began to show signs of disease after a month's time, and within seven weeks the inoculated plant was dead. After a time the suckers began to die and by March, four and a half months after the time of infection, the stool was dead with the exception of one plant which died a little later on. (Plate VIII, Fig. 2.) The organism was isolated in plates from these diseased plants on March 3, 1910. Twelve plates were poured and all were practically pure cultures of the one organism. On March 12, three red banana plants were inoculated from cultures from these plates. Two or three loops of the bacterial growth were spread on the base of one young leaf of each plant, and 6 to 8 needle pricks made through this into the petiole. Two plants of the same variety were pricked with a sterile needle to serve as controls. Within two weeks the inoculated leaf on one of the plants, No. 2, broke down at the point of infection and on April 1, 19 days after the inoculation was made, another leaf broke down. Within the next two weeks the whole plant died. (Plate VII, Figs. 1, 2 and 3; Plate VIII, Fig. 1.) The organism was reisolated from the diseased tissues of leaf and stem. The disease killed the other two plants in a similar fashion, except that the progress was not quite so rapid. The control plants showed no signs of disease at any time and are still (December 1910) perfectly healthy.

A similar set of inoculations was made again on March 15, on five plants each of the red and dwarf banana and of Manila hemp, *Musa textilis*. On April 1, one of the red bananas showed distinct signs of disease and within the next week the leaves on all of this variety began to give way and the plants were dead within seven weeks. (Plate VIII, Fig. 1.) It was not until the begining of May that the dwarf bananas showed signs of disease but after that time the symptoms developed rapidly, and by the middle of July all the inoculated plants were dead and many of the suckers from them were distinctly diseased or even dead. (Plate IX, Fig. 2.)

In the case of two stools however the suckers seemed to be healthy, as far as could be judged from external appearances at least. However when these suckers came to maturity in December the bunches of fruit were very poor, some of the fingers being black and rotten. When the plants were cut down it was found that many of the vascular bundles in the stem, fruit-stalk and fingers were discolored and filled with bacteria.[1]

The same organism was isolated from all the diseased red and dwarf plants of this set of inoculations.

The Manila hemp plants proved quite resistant as the only evidence of disease was a few discolored bundles in some of the leaves, but the plants still remain perfectly healthy in appearance. Ten inoculations with the bacterium have been made on Gros Michael banana plants, but this variety also seem to have a natural resistance to the disease. Though several of the inoculated plants have died, the progress of the disease was slow and some of the plants are still healthy. (Plate IX, Fig. 1.) Moreover this variety has never been found affected in nature.

From a lack of the necessary bacteriological apparatus and supplies but little has been done on the biology of the organism, but it has always been recognized in cultures by the fact that it quickly becomes black when grown on potato cylinders. It is also very short lived and loses its pathogenic power quickly, especially on media which contain starch. In these respects it is similar to *Bacillus solanacearum*. Inoculations have been made with it several times on Solanaceous plants but so far they have been unsuccessful. The writer is giving the name *Bacillus musae* to the organism and will at some future time give the complete bacteriological chart.

As plants suffering from this bacterial disease show many symptoms which are characteristic of the Panama disease of bananas the writer at first thought that the two diseases might be the same, but further study has showed that this is not the case. The two diseases are quite distinct. Though the vascular bundles of plants attacked by the Panama disease are discolored and frequently filled with bacteria, *B. musae* has never been isolated from such plants. The bacteria in the vessels are usually rapid growing gas formers, and, at least, so far as the writer's experience goes, are not pathogenic. The longitudinal splitting of the leaf sheaths which is a characteristic of the Panama

[1] Sections from the fruit-stalk and stem from one of these suckers have been sent to Dr. Erwin F. Smith, of the U. S. Department of Agriculture with the hope that he will be able to isolate the organism from them.

FIG. 1. FIG. 2. FIG. 3.

PLATE VII. **Red banana plant No. 2 inoculated with Bacillus musae on March 12, 1910. Check plant in background**

FIG. 1—Photograph taken on April 5. Three leaves had broken down in a manner characteristic of the disease; the arrow points to the place of inoculation. Leaves 2 and 3 were still green. FIG. 2—Photograph taken on April 10. All the leaves had broken at the base of the leaf-blade and were yellowish brown, with the exception of 4, which was green. FIG. 3.—Photograph taken on April 14. All the leaves had become brown and shrivelled.

FIG. 1 FIG. 2

PLATE VIII. **Banana plants inoculated with B. musae.**

FIG. 1—Photograph taken April 25. Red Banana plant No. 2 is shown on the left. The leaves were all dead and brown and the plant was practically dead. Plant to right is one of the red banana plants inoculated with hypodermic needle on April 15. The leaves had begun to break down. FIG. 2—Stool of moko plantain inoculated with *B. musae* on October 13, 1909. Photograph taken on March 3, 1910. The plant which was inoculated is designated by the arrow. This was the first plant inoculated with the organism.

FIG. 1. FIG. 2.

PLATE IX. **Banana plants inoculated with B. musae.**

FIG. 1—Gros Michael plant inoculated on January 17, 1910; photographed on March 3. This variety has more resistance to the disease than the red banana. FIG. 2—Dwarf banana (Musa chinensis) stool. The plant on the left was one of the five plants inoculated with *B. musae* on March 15, 1910, and died as the result. The sucker on the right became badly diseased from the parent plant, as evidenced by the blackened and withered tips of the leaves. The photograph was taken on July 13.

FIG. 1. FIG. 2.

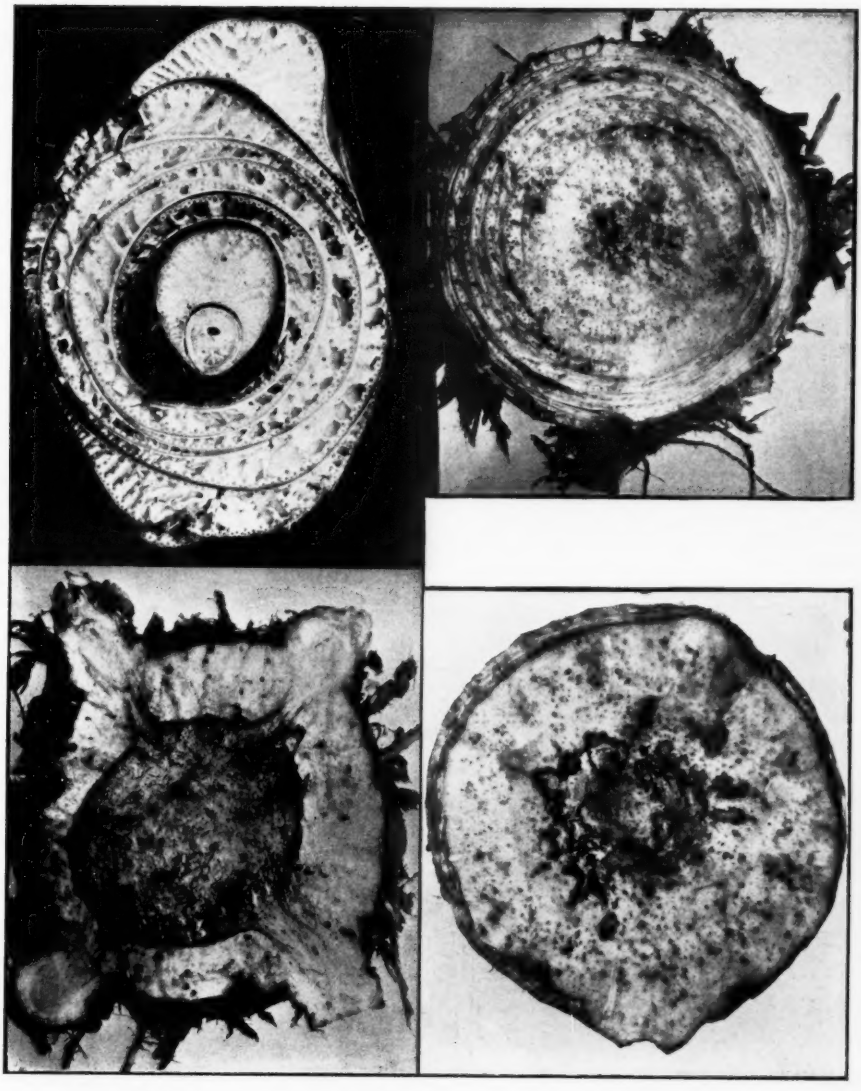

FIG. 3. FIG. 4.

PLATE X. **Transverse sections of diseased banana stems.**

FIG. 1—Section of the pseudo-stem of a sucker from one of the dwarf banana plants which were inoculated on March 15, 1910. The plant died down to the ground in a way similar to that shown in Plate IX, Fig. 2, and the suckers eventually became diseased and died. The central leaf was dead and the fifth youngest was also dead and decayed. FIG. 2—Section of the stem of same plant showing discolored vascular bundles. FIG. 3—Section of the basal part of stem of same plant showing the discolored vessels running out into the buds. The photographs for Figs. 1, 2 and 3 were taken on November 24, 1910. FIG. 4—Section of basal part of stem of red banana plant No. 2, inoculated with *B. musae* on March 12, 1910. Progress of disease in this plant is shown in Plate VII, and Plate VIII, Fig. 1. Plant was cut down on April 25, and photograph made of the stem in section to show bacterial cavities.

disease is not found in plants attacked by the "moko" disease. Moreover the Gros Michael plant which is very susceptible to the former disease seems to be naturally resistant to the latter.

A species of Fusarium was isolated in November, 1909, from a diseased Gros Michael plant and since that time the same fungus has always been found associated with the Panama disease both in Trinidad and in Suriname.[1] Evidence seems to point to the fact that this fungus is the cause of the disease, as was pointed out last year by Dr. Erwin F. Smith.

A root disease caused by a basidiomycetous fungus, evidently a species of *Marasmius* is found commonly in Trinidad but it is easily distinguished from both the Panama and "moko" diseases. Plants attacked by this disease can be easily pushed over as practically all the roots are rotten, but the tissues of the stem remain white and there is no discoloration of the vascular bundles.

The "moko" disease has been well controlled in Trinidad on several small plantings of plantains and bananas, purely by sanitary measures. As soon as a diseased plant is found it is dug up and destroyed on the spot, and all tools and implements used in the work sterilized by fire. It is needless to emphasize the importance of examining all suckers before they are planted.

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[1] The diseased plants from Suriname were sent to me by Mr. Goldsmith Williams, Manager of the Suriname Division of the United Fruit Company. I have recently had the pleasure of meeting Mr. Williams here in Trinidad and discussing with him the various diseases of bananas. J. B. R.

[2] Smith, E. F. A Cuban Banana Disease. Science 31: 754–755. May 13, 1910.

# A METHOD OF DEVELOPING CLAVICEPS

H. H. WHETZEL AND DONALD REDDICK

(WITH PLATE XI)

Since the publication of the beautiful illustrations of *Claviceps purpurea* by Tulasne in 1853, this fungus has been a favorite type used by many authors of text books as representative of fleshy pyrenomycetes. Sclerotia of this fungus are found commonly enough but the students rarely see the perithecial stage. This is probably not because stromata are not formed commonly, but because they are not sought at the right time, and because of their small size. In an attempt to develop stromata for class demonstration and use, we have met with such abundant success that our methods of procedure may be of interest both as to method and scientifically as well. Some earlier attempts by one of us to develop the ascigerous stage from dried sclerotia had proven failures and taking our cue from nature we thought to similate natural conditions to as great an extent as possible.

About August 10, 1907, one of us collected quantities of the sclerotia of *Claviceps purpurea* Tul. in the heads of rye (*Secale cereale*) which had come up "volunteer" in a field of oats near Swan, Noble Co., Ind. (Plate XI, Fig. 1). On August 20, 1907, sclerotia were collected at Ithaca, N. Y., in the heads of *Dactylis glomerata* and on August 23, 1907 we gathered them in the heads of *Festuca elatior*.

On the latter date quantities of sclerotia of the several collections were enclosed separately in ordinary screen wire and put on the ground under a grape arbor. They were not disturbed until April 6, 1908. On that date they were brought to the laboratory, placed on moist sand in a covered stender dish and kept at room temperature. On April 18, 1908, we noticed evidence of germination in the sclerotia from rye (Plate XI, Figs. 2 and 3). Those from *Dactylis* (Plate XI, Figs. 6 and 7) showed development first on April 20, and those from *Festuca* two days later. There were tardy developments in all cases so that it was May 23rd, before all stromata had developed. Aside from the slight variation in time of appearance there was a slight difference of color in the young stromata and a small difference in average size, those from rye having less of a pinkish tinge and averaging larger in size than those from the other two hosts.

With the above mentioned differences in mind, notes made from day to day on the development of stromata from sclerotia of rye will answer for all three.

April 19, 1908, (some of the young stromata at least 24 hours old). The first indication of development is the rupture of the cortex of the sclerotium and the appearance of a white globose head ½ mm. in diameter. This ascigerous portion is pushed up on a stem, increases in diameter and is sharply constricted at the base and thus sharply differentiated from the stem. The stem is pale lilac; broad at the base and tapering toward the apex.

April 22, 1908, "no indications of perithecia at this date; the head has enlarged slightly and has become pale straw color; the stem has lengthened perceptibly."

April 24, 1908, "yesterday the old stromata began to show punctations indicating the ostiola of the perithecia; to-day these are quite distinct, but the asci are still decidedly immature. The ascigerous portion is flesh color to pale fawn; up to 1.5 mm. in diameter. The stems are lilac at the apex and fade out to nearly white at the base; up to 1 cm. long. One sclerotium has 12 stromata developing from it." A white radiating tuft of hyphae developed about the base of many of the stems, especially after the stromata were nearly mature. (Plate XI, Figs. 3 and 7).

On April 19, 1908, sclerotia from the same collection, kept dry in the laboratory over winter, were placed on moist sand in a stender dish. May 23, 1908, there were no indications of development in any case.

At that time we had not seen an excellent paper by Rostowzew[1] which is written in Russian and in which he makes the point, by experiment, "that the sclerotia of ergot (*Claviceps purpurea* Tul.) not only preserve their vitality during one year only, but that they even lose it in less than one year, if they are subjected to complete drying out while in the resting stage."[2]

In attempting to make photographs we have noticed the very decided tendency of the stem to twist and turn. In order to obtain a good photograph without blurring, it was necessary to keep the stromata on a wet background and covered with a thin glass dish while the process of focusing was performed. The cover was removed and the water taken away with a blotter only long enough to make the

[1] Rostowzew, S. J., Beiträge zur Keimung des Mutterkornes *Claviceps purpurea* Tul. und *Claviceps microcephala* Wallr. "Journal Moscow Agricultural College" Book **III**: 1-16. 1902. 6 cuts in text. Abstract by Tranzchel in Bot. Centbl. **90**: 705-706. 1902.

[2] Literal translation made for us by Mr. J. Davidson, a Russian student in the Cornell College of Agriculture. This paper represents a very good piece of work, but is decidedly inaccessible owing to the fact that it is written in Russian. We shall be glad to have a competent stenographer make a copy for any one desiring it.

exposure. The twisting was also noticed in the culture dishes, but it was not given any study. Rostowzew studied this carefully and made some extremely interesting observations. He finds that this movement is an adaptation for the discharge of spores in a vertical direction. That the discharge of spores is only in a vertical direction was demonstrated by the placing of cover glasses in various positions near a mature stroma. Spores were obtained only on the glass suspended directly over the stroma, never at the sides nor beneath.

No inoculation experiments were made by us as no grasses were in flower as early as May 24th at Ithaca. Quantities of the sphacelial stage on rye were found in June, 1908, by one of us, in the locality from which sclerotia were obtained in 1907.

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PLATE XI. **Claviceps purpurea Tul.**

FIG. 1. Sclerotia of *Claviceps purpurea* in the head of rye. A small one near the center shows remains of the sphacelial stage. Natural size.

FIG. 2. Immature stromata from rye sclerotia. Natural size.

FIG. 3. Fully matured stromata from rye. 2 x.

FIG. 4. Longitudinal section of a mature stroma from rye. Photomicrograph—oc. 8 x ; obj. 16 mm.; distance from plate to object 33 cm.

FIG. 5. Photomicrograph of a perithecium shown in Fig. 4, Oc. 8 x ; obj. 4 mm.; 33 cm. from plate to object.

FIG. 6. Stromata on sclerotia from *Festuca elatior* natural size.

FIG. 7. The same (enlarged twice). Location of perithecia plainly evident.

FIG. 8. Perithecia ; stroma from *Festuca*. Photomicrograph—oc. 8 x.; obj. 16 mm.; distance from plate to object 33 cm.

FIG. 9. Single perithecium from *Festuca* stroma—oc. 8 x.; obj. 4 mm.; 33 cm. from plate to object.

FIG. 10. Longitudinal section of stroma developed from *Dactylis glomerata*. oc. 8 x.; obj. 16 mm. Distance from plate to object 33 cm.

FIG. 11. Perithecium enlarged. *Dactylis*. oc. 8 x.; obj. 4 mm. Distance from plate to object 33 cm.

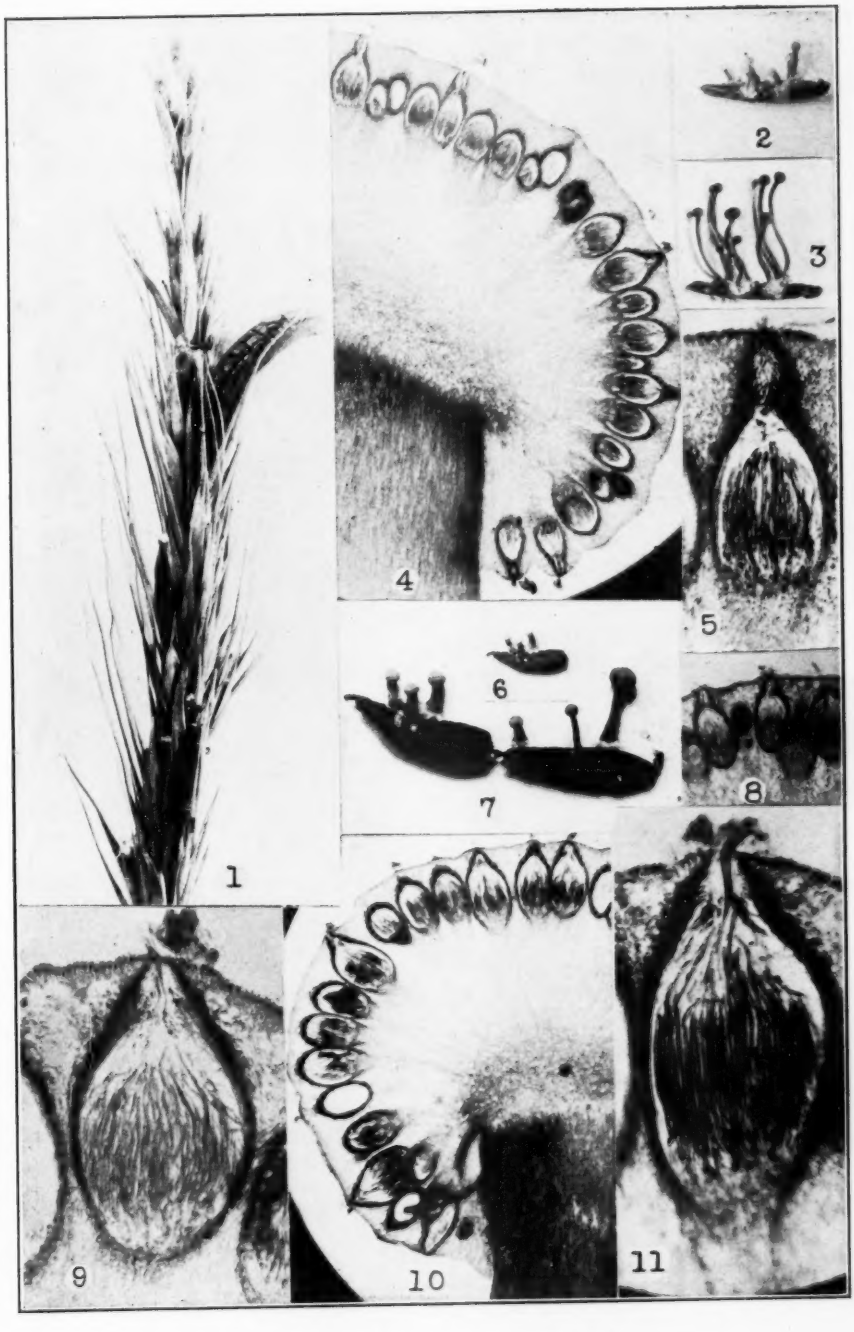


PLATE XI. **Claviceps purpurea Tul.**

# CROWN SWELLING DISEASE OF PEACH

J. B. S. NORTON

I have taken the following account of this disease chiefly from an unpublished paper recently prepared by Alvah J. Norman who first described this disease in the Report of the Maryland State Horticultural Society **12** : 149. 1910.

This disease was first brought to our attention by Mr. Malcomb Graham of Calvert County, Maryland. Mr. Graham had planted in the spring of 1908, a peach orchard of several hundred trees. When at his request a visit was made to the orchard in September, 1909, many of the trees were making poor growth and dying as if from starvation. Many had broken off about two inches under the ground. The diseased trees were scattered all through the orchard and the great difference in growth and condition of the trees gave the orchard a very ragged appearence, though no criticism could be made of the orchard management.

An examination of the trees in the orchard showed but slight connection between the lateral roots and the main root and stem, so that but little material from leaves and stem was available for use by the roots, and the water supply from the roots was also much reduced. There was a distinct swelling at the base of the stem extending upward four to eight inches, with frequent deep longitudinal cracks along its surface.

Being unable to locate a cause from a study of the orchard, samples were brought to the laboratory where a microscopic examination was made. In cross sections the bark at the swelling seemed to be of medium thickness while beneath it was a spongy layer of varying thickness composed of parenchymatous cells filled with starch and frequently interspersed with thin woody layers. The large size of the cells, the abundance of starch and absence of medullary rays easily distinguished the abnormal tissue from the normal peach wood. There was indication of broken-down cells at the origin of the lateral roots, and these roots seemed to be in the process of being cut off similar to the manner in which twigs of willow, poplar, etc., are often shed. This occurred on roots of all sizes. When the roots were broken off they left a perfectly smooth surface.

A study of many sections and attempts at cultures showed no signs of a causative organism.

It was learned at this time that several growers in western Maryland were losing many trees from the same trouble, and an examina-

tion of orchards in that section revealed the same symptoms. In every case the diseased trees had been planted in the spring of 1908 or in the fall of 1907. No new cases except from the plantings mentioned appeared during 1910.

It was easy to trace the trees back to the nursery, but no method of treatment in growing or shipping the trees was found to which the trouble might be attributed, unless it is connected with the use of poor seed. Some information of value concerning the use of poor peach seed by nurserymen was obtained. Much canning house seed is secured and the smaller, inferior pits, which resemble them in size, are sold for "natural" seed, the latter being especially sought by nurserymen for growing their stocks. Mr. Norman thinks the use of this inferior seed may have some connection with the Crown Swelling disease. I am inclined to look for the cause in some injury to the roots before planting or in the unusually wet spring of 1908, followed by extreme drouth.

MARYLAND AGRICULTURAL EXPERIMENT STATION,
COLLEGE PARK, MARYLAND

# A CONTRIBUTION TO OUR KNOWLEDGE OF THE MORPHOLOGY AND LIFE HISTORY OF PUCCINIA MALVACEARUM MONT[1]

JACOB J. TAUBENHAUS

(WITH PLATES XII, XIII AND XIV)

This paper records in brief form some of the observations made and conclusions arrived at during a rather extended study of the morphology, life history and control of *Puccinia malvacearum* Mont. The work was conducted in the laboratory of the Department of Plant Pathology of Cornell University during the years 1908 and 1909. The work constituted the basis for a thesis presented to the Faculty of Cornell University June 1909, in partial fulfillment of the requirement for the degree of Master of Science in Agriculture. The following is in the nature of a summary of some of the more important points recorded in that thesis.

## MORPHOLOGY OF THE FUNGUS

The mycelium of this fungus is branched, and intercellular. Haustoria are found but rarely. Old mycelium is often hyaline, while the young mycelium especially at the tip is granular and yellow, due to the presence of protoplasm and oil globules.

For eight to ten days after infection the mycelium spreads through the intercellular spaces of the host tissues. At the end of that time a mycelial cushion is formed under the epidermis. This cushion is made of large mycelial threads closely and irregularly interwoven. At the free ends of these threads little knobs are formed. Each knob bears several young teleutospores each of which matures at a different time (Plate XII, Figs. 1-5). The young teleutospores are at first one-celled. They are continually being formed even while old spores in the same sorus are in a state of germination. The teleutospores borne in the center of the sorus are naturally supported by longer pedicels than those formed at the edge of the spore cushion (Plate XII, Figs. 6 and 7). McAlpine[2] has called attention to the origin of a group of the teleutospores from a common hypha and states that the spore is at first without a septum. Fisher[3] has recorded the formation

[1] Presented before the Boston meeting of the American Phytopathological Society December 1909.

[2] McAlpine, D. Rusts of Australia, 179. 1906.

[3] Fisher, E. Die Uredinien der Schweiz. Beitr. Kryptogamenfl. d. Schweiz. 2 (Pt. 2) : 313. 1904.

of a partial septum in some cases but this McAlpine fails to find. We have never observed it. McAlpine (l.c. 178 and 179) records the finding of an occasional spore pedicel showing a septum such as is shown in Plate XII, Fig. 21.

Considerable variation in the form of the teleutospores is not uncommon. The normal spore is two-celled, slightly constricted at the center, and tapering towards both extremities. The two-celled teleutospores often vary in shape and in form (Plate XII, Figs. 14–22). One-celled spores (mesospores) are also very common (Plate XII, Figs. 8–13). Three-celled spores may also be found quite readily (Plate XII, Figs. 23–26). Four-celled teleutospores are more rare, though one or two of these may usually be found in a sorus (Plate XII, Fig. 27). This fungus has only the teleutosporic stage being primarily a leptopuccinia, but as we shall show later, functioning sometimes as a micropuccinia.[1] Spermogonia have never been observed so far as we can find. The teleutospores may germinate as soon as mature. They germinate readily in a humid atmosphere (Plate XIII, Figs. 2–7). An inflation is sometimes to be observed at the base of the promycelium where it emerges from the cell (Plate XIII Figs. 3 and 4). This swelling is more commonly found in the autumn. It was observed in germinated spores both from the hollyhock and from *Malva rotundifolia*. Dandeno[2] has called attention to the swelling of the promycelium just outside the germ-pore. He regards it as "peculiar to the mallow rust." He is at a loss to explain its significance. It is certainly not a uniform and constant characteristic of the germination of the teleutospores of this species and is not confined to spores from the *Malva* alone. Our observation that this inflation occurred most commonly in the autumn, may be explained by the more vigorous growth of the fungus at this time. The spores produced during this period, germinating with more vigor, send forth a vesicle thru the germ-pore that swells rapidly at first, later elongating but leaving this enlargement as evidence of early vigor and turgidity. Other evidences of autumnal vigor have been pointed out by us elsewhere in this article as well as by Dandeno (l.c. 70.) Usually only the apical cell of the spore germinates, though frequently the basal cell may also send forth a promycelium. The contents of the germinated cell are emptied into the promycelium. The latter elongates considerably and the protoplasm collects at its extremity. The promycelium not infre-

[1] See McAlpine l.c., pp. 11 and 178–179.

[2] Dandeno J. B. The Life History of *Puccinia malvacearum*. Ann. Rept. Mich. Acad. Sci. **9**:7. 1908.

quently branches out into a fork-shaped body (Plate XIII, Fig. 7), or may take the form of a germ tube, fails to produce sporidia and after four to five days disintegrates (Plate XIII, Fig. 9). Usually, after twelve hours, or less, the protoplasmic portion of the promycelium divides into four cells (Plate XIII, Fig. 8). The sporidia are formed in one of two ways: (1) The four cells of the promycelium may separate into four free and independent cells (Plate XIII, Figs. 10–12.) Each of these cells later sends out a little protrusion which elongates and swells up as the content of the mother cell is gradually passed into it, and thus a mature sporidium is formed which readily breaks away from the basidial cell and germinates (Plate XIII, Figs. 13–20). (2) In the other type, the four cells of the promycelium do not break apart, but each sends out a little sterigma which gradually swells up until the sporidium is formed, into which the content of the basidial cell is passed. The sporidium is then abstricted and germinates (Plate XIII, Figs. 21–24). The germination of teleutospores which were kept over winter is of the second type and this may be regarded as the normal method of spore formation. Here and there, however, it is seen that some promycelia form one or two chlamydospore-like bodies (Plate XIII, Figs. 25 and 26). The sporidia are readily carried by the wind and it stands to reason that they are usually lodged on the upper part of the leaf where infection takes place. In all our artificial inoculations, we have always inoculated on the upper part of the leaf, while the resulting sori appeared on the under side. In some cases the same pustule broke thru, both on the upper and the lower side of the leaf (Plate XIV, Fig. 1).

## LIFE HISTORY

*Spring and summer activities.* This fungus becomes active as soon as the severity of the winter is over. Epidemics seem to be regulated by the frequency of rains and dampness in the summer season. According to our observation the fungus is usually not as active in the spring and early summer as it is in late summer or autumn. It is readily transmitted from *Althea rosea* (hollyhock) to *Malva rotundifolia* or *M. crispa*, and vice-versa, as we have successfully proven by artificial cross-inoculation. McAlpine[1] reports it as occurring also on *M. sylvestris* L, *Lavatera plebeia* Sims, and *Plaginathus spicatus* Benth, in Australia, while Dandeno[2] adds to this list species of *Malvastrum*, *Didalcea*, *Malope* and *Abutilon*.

[1] McAlpine D. l.c. 178.

[2] Dandeno J. B. l. c., pp. 68-73.

*Autumn activities.* In the autumn as the hollyhocks cease blooming some of the seeds fall to the ground and germinate at once. Two weeks later the cotyledons of the seedlings may be found to be infected with the rust (Plate XIV, Fig 2). They appear to become infected on account of their proximity to the older, infested plants. In September and October, old as well as young hollyhock plants suffer severely. This also holds true for *Malva rotundifolia.* These and other observations do not seem to bear out the common opinion of gardners that seedling hollyhock plants are not susceptible to the disease.

*Winter activities.* This fungus is carried over winter in three ways; (1) As developing mycelium in the tender young leaves. (2) As mature hibernating teleutospores on the living or dead parts of the plant. (3) With the seed.

*Developing mycelium.* Halsted [1] appears to have been the first to suggest that the fungus winters as mycelium in the leaves. Dandeno[2] however, confirms Halsted's suggestion and in our investigation we also found this to be the case. Duggar [3] holds that there is no evidence that the mycelium is generally perennial. Late in the fall when growth has practically ceased, very young shoots are seen to be formed at the base of the plant. The shoots constitute the hollyhock or the malva plant of next year. While these young shoots later become abundantly infected, no signs of the infection are at this time apparent. About Ithaca, N. Y., this infection takes place near the end of November. About that time the ground begins to freeze and the hollyhock plants are usually mulched with a light covering of manure, while the malvas find enough protection among dead debris in the field. Late in December, if some of the plants are uncovered it will be found, especially in the case of the hollyhock protected by the mulch, that the young leaves have grown considerably and are beset with whitish dots on the pedicels and leaves. These are young sori which resulted from the late fall infection. If the plants are again uncovered in January, the young sori above mentioned are found to be larger and their color light lemon. On examining these sori again in February, they are found to have attained nearly their full size but the color is still unchanged. In March the color becomes

[1] Halsted B. D. Mycological Notes—III. The Hollyhock Rust. Bull. Torr. Bot. Club. **25**: 331. 1898.

[2] Dandeno J. B. l.c., pp. 68-73.

[3] Duggar, B. M. Fungous Diseases of Plants, 420. 1909.

light orange, but the teleutospores are still immature. They failed to mature in a moist chamber in the laboratory. On April 1st, these sori were still under the epidermis, but the color was now a deeper orange. By about April 10th, at Ithaca, mature sori were to be found in abundance, both on the hollyhock and on *Malva rotundifolia*. There seems to be ample proof that these teleuto-sori were the results of the late autumn infection for we found that new leaves, developed under the mulch during February and March, were free from the fungus and remained so until May after spring infection had occurred. Other evidence seems to show that no infection takes place in the winter. We have collected old teleutospores from old hollyhock leaves in January and February, but have not found them in a state of germination though they germinated readily in the laboratory.

*Hibernation of teleutospores.* Plowright[1] suggested that the teleutospores hibernate. He believes that some of the sori from the stems drop out on the ground where they pass the winter. Massee[2] also believes that the teleutospores survive the winter on dead and decaying leaves. However, neither Plowright nor Massee offered any experimental evidences in support of their statements. Dandeno[3] attempted to solve this problem thru actual experiments. He made repeated attempts to germinate mature spores brought in on living leaves during the winter and early spring. Such spores proved to be either already germinated or seemed dead. The following, in his own words, are the results of his investigation: "The idea of teleutospores wintering over had to be abandoned. . . . A large amount of dead leaves were strewn the following spring among certain patches of mallows which were to all appearances free from the rust. . . . The infected litter did not seem to produce any results whatsoever."

In our investigation the results obtained tend to bear out the claims of Plowright and Massee, that mature teleutospores can live over winter. However, we find it necessary to add that these teleutospores must have been formed late in the autumn, otherwise they would all have germinated. We find no evidence as held by Plowright that sori drop out onto the ground and there winter the resting teleutospores. The data on which we base our conclusions are as follows: Nov. 26, 1908, infected living hollyhock leaves were gathered and put into wire baskets which were laid under a pine tree not far from the holly-

[1] Plowright, Ch. B. On the Hollyhock Diseases. Gard. Chron. **18**: 617. 1882.

[2] Massee, G. Hollyhock Rust. A Text Book of Plant Diseases, 252–253. 1899.

[3] Dandeno, J. B. l.c. 69.

hock experimental field. Leaves from the same plants were taken indoors and kept in the culture room where the temperature was low. Germination tests were made from the material thus stored away. December 2, teleutospores taken from the leaves kept both outside and indoors germinated readily in 24 hours, producing an abundance of sporidia. December 26, germination tests from the same material gave results similar to those obtained Dec. 2. Tests made Jan. 6, 1909, from the same material gave like results. Feb. 6, from the same material as above, a smaller percentage of the teleutospores had germinated after 24 hours. March 2, using the same material no germination resulted in either case after 24 hours. April 10, using the same material no germination was apparent after 24 hours. We then decided to keep these teleutospores a longer time in the drops of water to see whether they would finally germinate. On April 12, slight germination was apparent. On April 13, these same teleutospores had germinated profusly, and on April 14, sporidia were formed and these germinated readily. It had taken six days for the teleutospores to germinate. The negative results of March 2, were evidently due to the fact that the teleutospores were not kept a longer period in the drops of water. The experiment of April 10, was twice repeated, using from the same material, and the same results were obtained. This held true both for the leaves kept out of doors and those kept indoors. We found it advisable to wash the dry leaves in running tap water, then in distilled water in order to remove as far as possible the spores of saprophytic fungi.

*With the seeds.* Farlow[1] says that this fungus was introduced in the U. S. with imported seeds of *Malope*. Massee[2] says the fungus winters in the embryo of the seed. Dandeno[3] concludes that the disease is not carried over in the seeds as is held by Massee. In our investigation we find the disease to be carried over *with* the seeds. In tihs connection it is to be observed that in the hollyhock the seeds are usually free from sori, because until mature they are enclosed and protected by the involucral bracts. Infection is often abundant on the bracts. In the case of *Malva rotundifolia*, the carpels are constantly exposed, as the bracts are reflexed hence we commonly meet with badly diseased carpels. We obtained no evidence that the fungus winters

[1] Farlow, W. G. *Puccinia malvacearum* Mont. in Massachusetts. Bot. Gaz. II: 309-310. 1886.

[2] Massee, G. l.c. 291.

[3] Dandeno, J. B. l. c. 68–73.

in the embryo of either the *Malva* or *Althaea* as held by Massee. On November 26, 1908 a large quantity of infected fruits and carpels of *Malva rotundifolia* were gathered and kept over winter in paper bags in the laboratory. These fruits and carpels were covered with mature sori. On April 1st, 1909, one hundred of the above seeds intermixed with the diseased involucres of the fruit were planted in the greenhouse. April 10th, 46 seeds had germinated. April 12th, one seedling (Plate XIV, Fig. 4) showed the beginning of a sorus on one cotyledon and on April 22 this sorus was well developed and contained mature teleutospores. On April 24th, one hundred of the above seeds were planted in the greenhouse, taking care to remove all the involucral bracts. Another lot of one hundred seed from the same fruits were planted *with* the involucral bracts in a separate flat. On May 4th, both lots of seeds had germinated. On May 7th, 60 percent of the seedlings in both lots showed signs of young sori, both on the cotyledons and on the hypocotyls. On May 14th, these sori were all mature. These could not be attributed to infection from diseased plants outside, since they were all well protected within the greenhouse. Infection here can be attributed directly to the hibernating teleutospores in the sori from the infected bracts and carpels. The seedlings were allowed to grow and as they were thickly sown every plant in the flat soon became diseased.

## CONCLUSIONS

The teleutospores of *Puccinia malvacearum* Mont. originate in groups as little buds on knobs at the tips of mycelial threads which together constitute the spore cushion.

The inflation of the promycelium just outside the germ-pore is not a constant character in the germination of the teleutospore and is not peculiar to the spores produced on the mallow as held by Dandeno.

The teleutospores are subject to great variation both as to size, form and number of cells.

There are two common types of sporidial formation: (1) from free cells formed by the breaking up of the promycelium, and (2) the normal type where the sporidia are formed on stergimata from the cells of the septate promycelium.

*Puccinia malvacearum* Mont. on the hollyhock is the same as that on *Malva rotundifolia* and *Malva crispa*, as proven by cross inoculation.

Seedling plants of susceptible hosts are no more resistant to infection than are older plants.

*Puccinia malvacearum* Mont. winters over as; (1), living mycelium, late

fall infections developing thru the winter and maturing their spores in the spring; (2), hibernating teleutospores on old living or dead leaves; and (3), on the seeds or bracts (not *in* the embryo).

The parasite appears to be more vigorous and virulent during autumn than at any other time.

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PLATE XII. **Puccinia Malvacearum Mont.**

FIGS. 1–7. Showing the formation of young teleutospores and the attachment of the same to the mycelium.

FIGS. 8–13. Variation in form of the one-celled (mesospores) teleutospores.

FIGS. 14–22. Variation in the form of the two-celled teleutospores.

FIGS. 23–26. Variation in the form of the three-celled teleutospores.

FIG. 27. A four-celled teleutospore.

PLATE XIII. **Puccinia Malvacearum Mont.**

FIG. 1. Typical mature teleutospore.

FIGS. 2–6. Different stages in the growth of the promycelium.

FIG. 7. Fork-shaped promycelium.

FIG. 8. Promycelium dividing into four cells.

FIG. 9. Promycelium resembling a germ-tube.

FIGS. 10–12. Showing the four cells of the promycelium breaking apart.

FIGS. 13–16. Promycelial cells germinating and forming the sporidia.

FIG. 17. Empty promycelial cell.

FIG. 18. Mature sporidia.

FIGS. 19–20. Germinating sporidia.

FIGS. 25–26. Formation of chlamydospore-like bodies in old promycelia.

PLATE XIV. **Puccinia Malvacearum Mont.**

FIG. 1. Cross-section through hollyhock leaf showing teleuto-sorus breaking through on both sides.

FIG. 2. Seedling hollyhock with teleuto sori on cotyledons.

FIG. 3. Sori on pedicels and involucral bracts of *Malva rotundifolia*.

FIG. 4. Seedling of *Malva rotundifolia* grown in green house from rusted seed which had been kept over winter.

FIG. 5. Secondary sori formed about large primary sori on underside of hollyhock leaf.

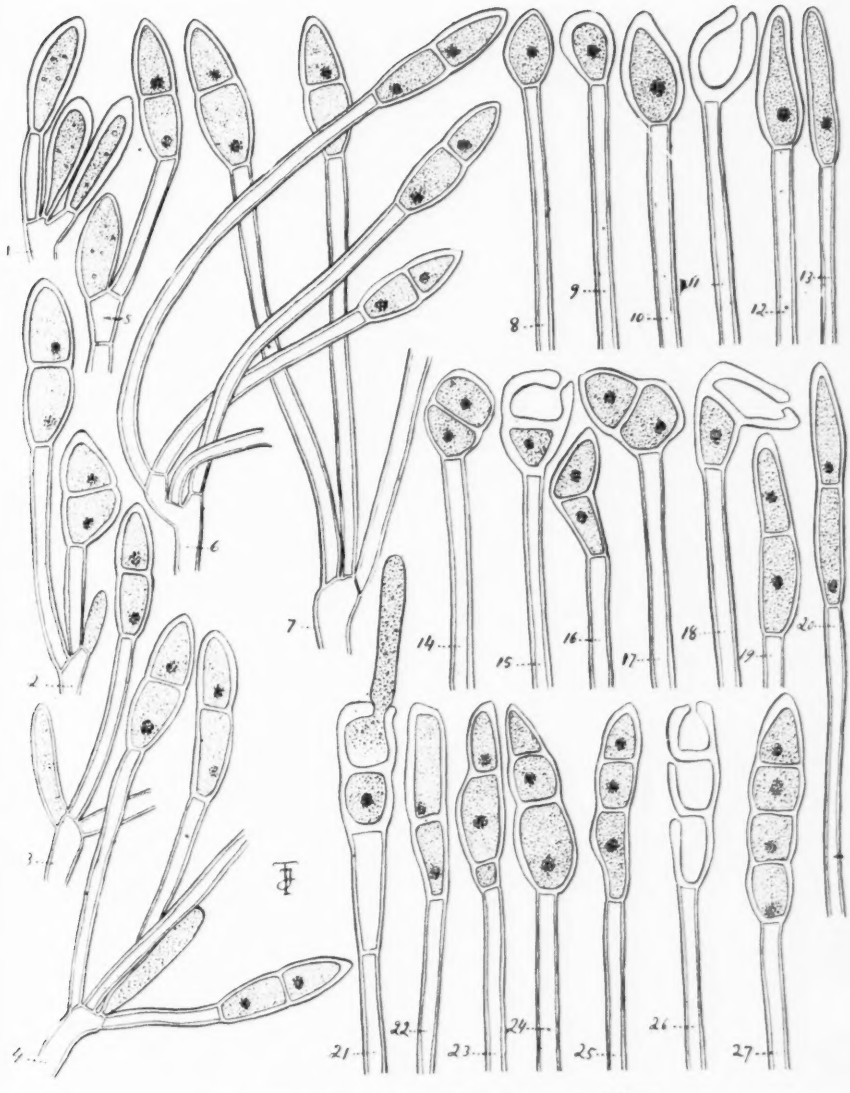

PLATE XII. **Puccinia Malvacearum Mont.**

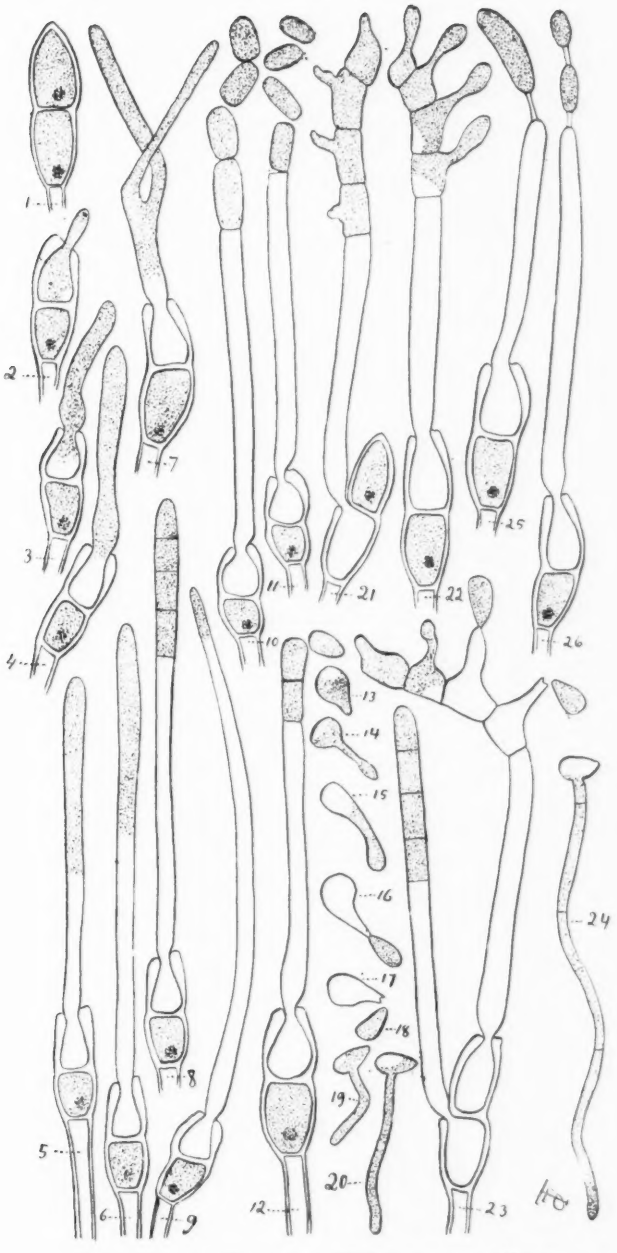


PLATE XIII. **Puccinia Malvacearum Mont.**

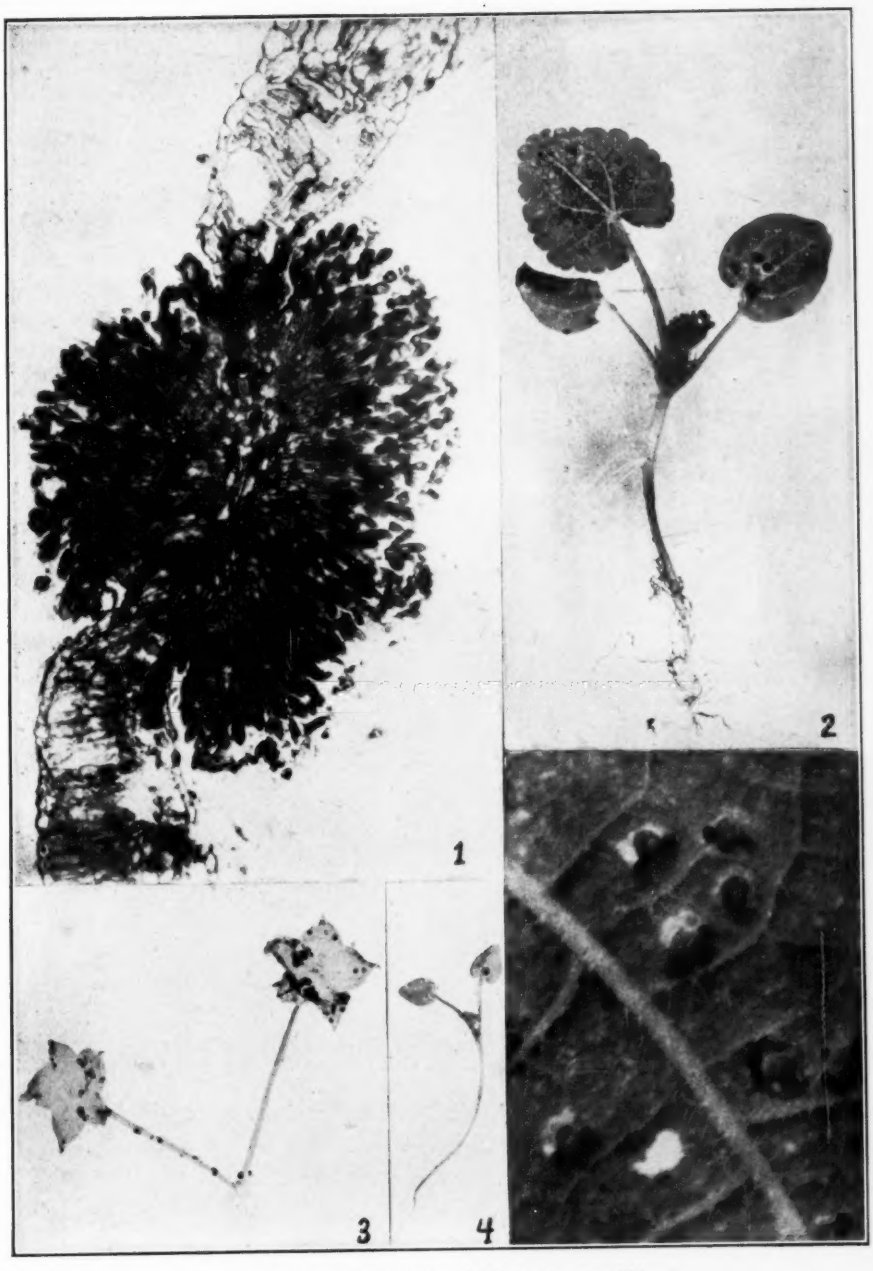


PLATE XIV. **Puccinia Malvacearum Mont.**

# SPHAEROPSIS TUMEFACIENS, NOV. SP., THE CAUSE OF THE LIME AND ORANGE KNOT

(With Plate XV)

Florence Hedges

In the spring of 1904, several branches of lime, *Citrus hystrix*, DC., var. *acida* (Roxb.) Bonavia, bearing knots, were received by the Laboratory of Plant Pathology, U. S. Department of Agriculture, from Jamaica. The specimens were accompanied by the following statements:

"The lime trees in Westmoreland [in the western part of the island] are infested with galls which in some instances appear to do as much harm as the scale insects. The galls are found on old and young trees, but usually they grow first on fairly old limbs. These limbs then send out strong young shoots for a time, but speedily get exhausted and die, large numbers of limbs dying until many fine trees are killed, or so nearly so as to be useless."

From these knots a fungus was isolated,[1] numerous inoculations with which resulted in the production of tumors. From the latter repeated isolations and successful reinoculations were made proving beyond a doubt that this was the parasite. In January, 1909, what proved to be the same fungus was isolated from orange knots from Jamaica, and with this strain also artificial infections, reisolations and reinfections were repeatedly obtained.

The knots are usually approximately round but they may be somewhat elongated—the long axis being parallel to that of the infected branch. They are attached by a broad base and vary from swellings the size of a pea to knots 2 to 3 inches in diameter. The young knot is covered by the smooth green bark but this usually soon splits, dies, and falls away leaving the woody tissues exposed or covered with a softer, more or less crumbling layer (modified bark) about the thickness of ordinary bark. When the mycelium is present in abundance its dark-colored hyphae impart a black appearance to the tissues of the knot. Frequently, however, large knots occur which contain a very small quantity of mycelium and are still covered with normal bark. Frequently witches brooms grow from the knots.

Despite the large amount of cultural work done on the fungus isolated from these knots no spores were observed either in cultures

[1] The first isolation of the fungus and the first inoculations into lime trees were made by Lloyd S. Tenney under the direction of Dr. Erwin F. Smith.

or on the host, until the spring of 1909, at which time a few pycnidia containing spores were discovered in a 3-months-old cornmeal flask culture of the orange strain. From this a vigorously fruiting strain has developed. All other strains, whether from the orange or the lime, have fruited in culture media either very rarely or not at all, though some of them have produced spores on the host. Thus far no perithecia have been observed, but pycnidia and spermogonia occur in great numbers in artificial infections on the host and in cultures of the vigorously fruiting strain. Sometimes in cultures these are embedded in a stroma in which the pycnidia and spermogonia occur merely as chambers without a distinct wall. The occurrence of a stroma, however, is a very inconstant character. It has never been observed upon the host; it does not occur in all culture media, nor is it a constant character on culture media on which it usually occurs. For example, in potato cultures of a nonfruiting strain or in which only scattering pycnidia are present, there is a thick, tough stroma, but if potato cultures are fruiting abundantly so that in four or five days after inoculation the surface is covered with pycnidia, the thick tough stroma is replaced by a very thin easily crushed layer consisting for the most part of pycnidia crowded more or less closely together and having a distinct pycnidial wall. The pycnospores, although usually continuous, are rarely 1-septate on the host. In cultures, however, spores with 1- to 2-septa occur quite frequently, and occasionally 3- or 4-septate spores have been observed. The continuous spores, however, germinate readily and, therefore, cannot be considered immature.

These variations upon culture media have made the work of classification difficult but since, as all who have studied fungi from cultures well know, a fungus cultivated under artificial conditions is capable of doing almost anything and since it seems reasonable to suppose that the *normal* form of a fungus is that upon the host, the form there found has been considered by the writer the typical one, and the fungus described and named accordingly. Another inconstant character is the color of the spores, but although these often show no trace of color even in mass, on the other hand the individual spores are too often a decided yellow to assign the fungus to the genus *Macrophoma*. The yellow color is deeper in cultures, but, though pale, it is unmistakable on the host also. The fungus has, therefore, been put into the genus *Sphaeropsis* and named *Sphaeropsis tumefaciens* nov. sp., with the following Latin diagnosis.

**Sphaeropsis tumefaciens** nov. sp.

Peritheciis subglobosis, papillatis, atris, ostiolatis, initio epidermide tectis, demum erumpentibus, congregatis vel solitariis, 152–224 $\mu$ x 120–

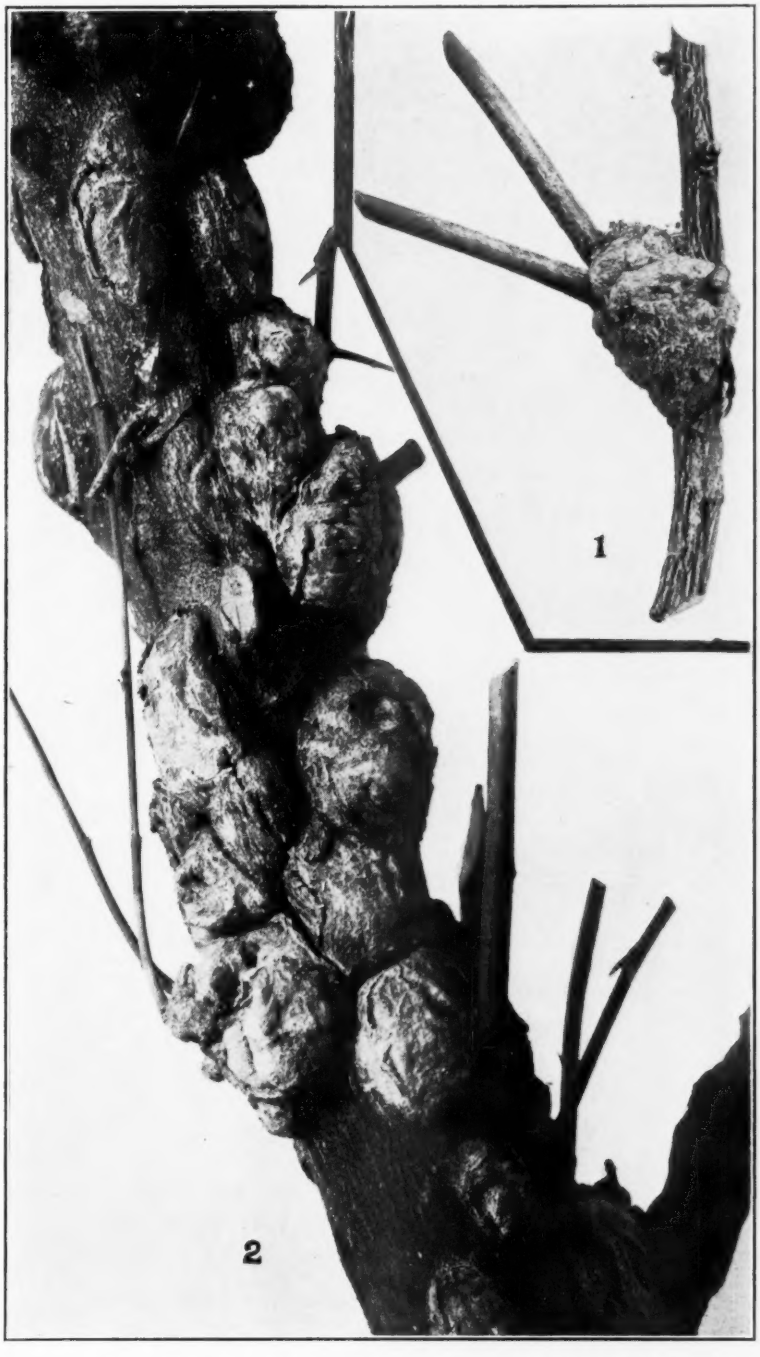


PLATE XV. **Knots caused by Sphaeropsis tumefaciens.**

FIG. 1. Natural infection on orange. Jamaica, W. I.

FIG. 2. Trunk of lime tree inoculated with *Sphaeropsis tumefaciens*, Washington, D. C.

192 μ, membranaceo-carbonaceis; sporulis oblongis vel ovoideis, utrinque rotundatis vel subacutis, quandoque alia vertice rotundata, alia acuta, quandoque inaequilateralibus curvatisque leviter, granulosis, continuis, raro 1-septatis (saepe in culturis 1-2, quandoque 4-septatis) hyalinis vel lutescentibus, 16–32 μ x 6–12 μ (raro in culturis 36 μ x 8 μ) basidiis filiformibus, quandoque paene aequilongis suffultis; spermatiis saepe in eisdem peritheciis vel in spermogoniis separatis, minutis, continuis, cylindricis.

Mycelio initio hyalino, demum fuscescente, ramoso, multiseptato; hyphis 0.4–14 μ in diam., corticem, lignum medullamque penetrantibus, tumores facientibus.

Hab.: In tumoribus *Citri hystricis* DC. var. *acidae* (Roxb.) Bonavia, et *Citri aurantii*, Jamaica, B. W. I. Saepe in culturis stromatem facit, in qua perithecia cavitates solitariae vel confluentes sunt. In culturis saepe perithecia colla habent et in stromate immersa sunt, et sporulae in cirris emittuntur. Gelatinam liquefacit. Casein in lacte sterili segregatur et tandem solvitur. Amylum destruit.

A bulletin containing a more detailed description of the fungus, its behavior on culture media, and inoculation experiments, is in course of preparation.

LABORATORY OF PLANT PATHOLOGY,
U. S. DEPT. OF AGRICULTURE, WASHINGTON, D. C.

## REVIEWS

Winter-killing of twigs, cankers and sun-scald of peach trees. Rolfs, F. M. Bulletin 17, Missouri State Fruit Experiment Station, Mountain Grove, Missouri, 101 pages, 13 plates, 1910.

This bulletin gives a detailed account of an investigation of the causes of certain forms of gummosis, die-back, canker, "sun-scald" and "frost injury." It was found that in most cases where peach trees were affected by injuries popularly attributed to various causes, a fungus, *Valsa leucostoma*, usually in its pycnidial condition, was present in the affected parts. Large series of cultures and many inoculation experiments carried out by the author have shown that the greater part of these injuries is due to this fungus. Infection appears to take place generally through buds or wounds. The vigor and vitality of the tree determine, to a great extent, the amount of injury produced. Wind, rain, insects and birds appear to be the chief means of distribution of the spores. Both spore forms of this fungus from the peach, plum, apricot, red cherry and wild cherry were interchangeable on these hosts. The form on the cultivated cherry, wild cherry and peach shows characters which lead the author to designate it as a variety, *V. leucostoma* var. *cincta*. That found on the apricot and plum, is called *V. leucostoma* var. *rubescens*.

As a means of controlling this trouble it is recommended that all infected twigs and parts be removed and burned, and all possible means be employed to keep the trees in a thoroughly vigorous and healthy condition. Experiments in the application of Bordeaux mixture and lime-sulphur (4 treatments) greatly reduced the amount of twig infection, but its practical value in controlling the disease is not yet regarded as fully established. The bulletin shows evidence of a great amount of patient investigation, and the results seem to determine definitely the relationship of this fungus to the major part of the troubles described as they occur in Missouri. It is unfortunate that the paper is marred by such a large number of typographical errors. The page of errata inserted covers but a small part of them. The twelve half-tone plates illustrating the paper are very unsatisfactory. The drawings reproduced in the last three plates evidently represent a great amount of careful work which is largely lost in the reproductions. It is greatly to be regretted that a piece of apparently thorough and reliable work of this sort should not be published in a more satisfactory manner. It is an injustice to the author as well as the public.

C. L. SHEAR

## *MINNEAPOLIS MEETING OF AMERICAN PHYTOPATHOLOGICAL SOCIETY*

The second annual meeting of our Society was held at Minneapolis, Minn., Dec. 28–30, 1910, in affiliation with the American Association for the Advancement of Science. About thirty members were in attendance, and a program of 28 papers was presented. A joint session with Section G of the American Association for the Advancement of Science and the Botanical Society of America, was held at the Minnesota Agricultural College, Thursday, Dec. 29, and two other sessions at the University of Minnesota. The Society is greatly indebted to the local Committee and especially to Dr. F. E. Clements, for the excellent facilities and conveniences provided for the meetings.

The Constitution of the Society which had been drafted and approved by the Council, was adopted by the Society.

The following officers were elected for 1911:

*President*—Prof. A. D. Selby, Ohio Agricultural Experiment Station, Wooster, Ohio.

*Vice-President*—Dr. R. A. Harper, University of Wisconsin, Madison, Wis.

*Secretary-Treasurer*—Dr. C. L. Shear, U.S. Dept. of Agriculture, Washington, D.C.

*Members of Council*—Dr. G. P. Clinton, 1 year. Conn. Agricultural Experiment Station, New Haven, Conn.

Dr. Erwin F. Smith, 2 years. U. S. Dept. of Agriculture, Washington, D. C.

The two ex-officio members of the council are:

Dr F. L. Stevens, retiring President; Dr. L. R. Jones, Chairman of Board of Editors of PHYTOPATHOLOGY.

Pledges to the guarantee fund, amounting to about $400.00, having been received, the Council, after due consideration, recommended the publication of a Journal to be known as PHYTOPATHOLOGY. The Society adopted the recommendation and the following editorial board was elected:

*Editors*—L. R. Jones, C. L. Shear, H. H. Whetzel.

*Associate Editors*—G. P. Clinton, E. M. Freeman, H. T. Güssow, F. D. Heald, Haven Metcalf, W. A. Orton, W. M. Scott, A. D. Selby, Erwin F. Smith, Ralph E. Smith, F. L. Stevens and Roland Thaxter, with Donald Reddick as Business Manager.

A large number of new members were elected.

The reports of the Secretary and Treasurer were read and approved.

The following committee on legislation concerning plant diseases was appointed: Mel T. Cook, F. L. Stevens, F. C. Stewart, H. T. Güssow, and A. D. Selby ex-officio.

The Committee on common names for plant diseases presented the following report which was adopted and the Committee continued.

"Your committee beg to urge the advisability of taking some action which may tend toward greater uniformity in the matter of common naming of plant diseases and would suggest to that end the following, namely:

The adoption of lists of accepted names.

They would suggest for this that this list be added to from year to year in the following manner:

1. That the list be prepared, printed and sent to each member of this society.

2. That the list be presented before your committee and all names not receiving unanimous approval be stricken out.

3. That any name objected to in writing by any member of this society shall be stricken out.

NOTE—The objection must be mailed to the secretary of the society at least two weeks prior to its annual meeting.

4. That the list be circulated in printed form at the Annual Meeting and adopted at a regular meeting, after striking out any name objected to by any member present.

5. That a standing committee be appointed whose duty it shall be to prepare lists of names for presentation to the society.

F. L. Stevens, Chairman."

A list of 90 names of plant diseases was recommended by the Committee. This will be published and distributed later.

*Resolved*, That the annual dues of this Society for the year 1911, shall be one dollar ($1.00) and supscription to the Journal, PHYTOPATHOLOGY, for members shall be two dollars ($2.00.)

The next annual meeting will be held at Washington, D. C., Dec. 27–31, 1911, in affiliation with the American Association for the Advancement of Science.

The following papers were presented. Some are published in the first number of PHYTOPATHOLOGY, or in the present number. Abstracts of others, so far as received, are given here.

*Tannin in Relation to the Enzymes of the Plant Cells.* MEL T. COOK

This paper presents a continuation of the previous work on the functions of tannin, the author having the assistance of Dr. H. P. Bassett, organic chemist, and Mr. J. J. Taubenhaus, plant pathologist. The work consisted of comparative studies of the pomaceous and other fruits and the fungi that occur upon them at different seasons. It was found that the tannin content varied with injuries and with the time elapsing between removal from the tree and analysis. Two enzymes were finally found, an oxidaze and a catalaze. The former is believed to act upon the gallic acid or other constituents of the fruit when subjected to injury, and to form a tannin or tannin-like body which is toxic to fungi. This tannin or tannin-like body is believed not to exist in any part of the normal fruit except the peel previous to injury or removal from the tree.

*The Persistence of Bacillus amylovorus in Pruned Apple Twigs.* H. R. FULTON

Four lots of blighted twigs of apples were cut and allowed to remain on the ground under different weather conditions from July to late September. Tests for viability were made by inoculating healthy twigs with bits of bark. Out of 35 twigs, 31 twigs, or about 9/10, were inactive at the end of seven days; and the majority of these had become inactive in three to five days. There was indication that persistence was longer with low temperature and moist conditions, than with high temperature and either dry or moist conditions. Bacteria in the dried exudate remained viable several days longer than bacteria within the tissues. The quick death of blight bacteria in cut twigs, and the remote chance of their being transferred to living trees, brings in question the necessity for rigid destruction of blighted twigs after their removal.

*The Industrial Fellowship in Plant Pathology.* H. H. WHETZEL

During the past two years eight industrial fellowships have been established in the Department of Plant Pathology of the New York State College of Agriculture at Cornell University. Each of these have been established for the purpose of investigation of the diseases of some particular crop, or some phase of plant disease control. Five of the eight have been established by growers, or associations of growers; three by commercial firms directly interested in plant disease control.

These fellowships, which provide sums ranging from $750 to $3000 per annum for from two to four years, represent genuine financial cooperation between the growers and the State. The Department provides the necessary laboratory equip-

ment and supervision. The work under the fellowships is conducted mainly in field laboratories about the State.

It is believed that these fellowships will result in a more prompt and practical solution of pressing plant disease problems, and will enlist the more direct interest and assistance of growers in the work.

*Sclerotium rhizoides (Auersw.) on Calamagrostis canadensis.* A. B. STOUT

The investigations here reported reveal some important facts concerning the hitherto unknown life history of this fungus. Briefly summarized the findings are as follows:

About Madison, Wis., this fungus appears as a destructive parasite on the young leaves of *Calamagrostis canadensis* upon which it develops as a felt of aerial mycelium with production of bead-like sclerotia varying from 1 to 5 m.m. in diameter. No spores have been found on this mycelium. All efforts to find the selerotia germinating in nature or to induce them to develop further have been fruitless.

That the fungus is of perennial habit has been proven both by experiment and by anatomical examination. The mycelium has been found coexistant in leaves, buds, stem, rhizomes, scales and roots of the same plants. The fungus is parasitic on leaves, less so in buds and apparently slightly so in rhizomes and roots.

In leaves and buds the habit of growth is both epiphytic and endophytic. High humidity favors epiphytic development and the formation of sclerotia. In tissues the mycelium is chiefly intracellular.

In roots and rhizomes the fungus behaves as a mycorhiza. Here it is both ectotrophic and endotrophic forming a thin loose layer on the surface and also ramifying through the cortical tissues where coils of intracellular mycelium are produced and also at times conspicuous intercalary bladders.

The fungus has been grown and studied in pure cultures on various media for nearly a year. Abundant development of mycelium with sclerotia is secured with ease. The sclerotia thus grown show a diversity which ranges from crusted spongy layers to well formed sclerotia. The largest of these far exceed in size any that have been obtained in nature. Oidia are produced in culture.

Investigations are now under way to secure germination of sclerotia, to perform various infection experiments and to test physiologically the mycorhizal relationships to the host.

*The Relation of Temperature to Spore Germination and Infection with Cystopus.* I. E. MELHUS

It has been found that the conidia of *Cystopus* and some other Oomycetes which germinate sparingly or not at all at greenhouse temperatures (22 degrees centigrade or above) readily germinate when chilled for a period of from two to five hours at about 10 degrees centigrade. It has been shown by a large number of experiments that similar chilling also favors infection. Thus stock cultures of radish seedlings inoculated with *Cystopus candidus* and chilled for ten hours at 10 degrees centigrade showed over 95 percent of the seedlings infected; while the controls not chilled and kept at ordinary greenhouse temperatures showed only a low percentage of infection. The favorable effect of chilling is not only evident in the case of *Cystopus* but also in *Phytophthora infestans* and *Plasmopara viticola*. The details of the above experiments will probably appear in a later number of this Journal.

*The Rusts of White and Red Clover.* FRANK D. KERN

Read by title. Published in Phytopathology No. 1.

*Black Leg or Phoma Wilt of Cabbage, a New Trouble to the United States Caused by Phoma oleracea Sacc.* THOS. F. MANNS. Published in Phytopathology No 1.

*The Fusarium Blight and Rot of Potato. Field Experiments in Prevention.* THOS. F. MANNS

This disease has become a serious menace in fields where some of the shorter potato rotations have been practiced. The symptoms have been studied and the disease verified by artificial culture methods. The trouble is widely distributed in Ohio. Field work in its control has been carried on with six different varieties of internally infected potatoes. Some success in its control has attended the experiments in which the stem (navel) end or the diseased part of the tuber has been cut away, then followed by the formaldehyde treatment.

*The White Pine Blister Rust.* PERLEY SPAULDING

This paper is a report of progress for 1910. Diseased trees were found in plantations which were very carefully inspected in 1909. No diseased trees less than three years old have yet been seen; hence inspection of one and two year-old trees is useless. There is grave danger from the importation of 2-year-old trees, as they are liable to develop the disease a year later; this has actually happened in very large lots both in 1909 and in 1910. The disease has been imported a number of years previous to 1909, but has not yet become established. J. Heins' Sons nursery has sent us over 95 per cent of the diseased stock. Moreover, they have sent it for years, and, so far as we know, have it still in the nursery. Diseased stock was found in 1910 which was obtained of the three French firms: Levavasseur & Fils of Ussy, Barbier & Co. of Orleans, and E. F. Dickinson of Chatenay. Ribes are again appearing in plantations where they were removed in 1909. The cost of inspection of diseased plantations already exceeds the entire value of the trees. The disease has been found in the additional States of Ohio and Indiana. While the disease is held in check, the prohibition of the importation of white pines is imperative, to prevent its finally becoming established here.

(To be concluded.)

## EDITORIAL ANNOUNCEMENT

It is the intention of the Editors to publish in the current volume a list of the plant diseases of economic interest new to North America which have been reported or described during the year 1910. It is probable that this feature will be continued each year and it is hoped that it may be made reasonably complete. The list will include all economic diseases described for the first time and also the first recorded occurrence in America of such maladies as have been previously known in other countries, with definite citations to the literature in which the disease is reported or described. To be of most value, the list should be made to include abiotic diseases as well as those due to bacteria or fungi. The cooperation of all authors is invited in this matter and the request is made that separates of publications containing reports or descriptions of new diseases be sent to Dr. F. D. Heald, University of Texas, Austin, Texas, who will have the preparation of this list in charge.